

FR 72-1442

BASIC RESEARCH IN PRECISE MEASUREMENT

FINAL REPORT

FOR

PHASE II

**NIMA Declassification/Release Instructions on File**

JUNE 1972

Prepared by

25X1A



ABSTRACT

This document is the final technical report for Phase II in a program of Basic Research in Precise Measurement of Photographic Images. All of the work was performed by personnel of the [REDACTED] [REDACTED] during the period April 1971 through June 1972. The following five tasks constitute the subjects of Phase II:

- Task 1. Automatic Pointing
- Task 2. Evaluation of Color Measurements
- Task 3. Image Shearing Eyepiece Evaluation
- Task 4. Viewing Illumination
- Task 5. Accuracy Improvement

Detailed discussions of the work performed and the results accomplished on each task have been reported on in appendices to this final report. The purpose of this document is to list the reports generated under this contract and indicate the scope of the work performed.



TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1. INTRODUCTION.....	1
2. TECHNICAL APPROACH, RESULTS, AND CONCLUSIONS.....	2
2.1 Task 1 - Automatic Pointing.....	2
TABLE OF CONTENTS OF APPENDIX A.....	4
2.2 Task 2 - Evaluation of Color Measurement.....	5
2.2.1 Task 2 - Subtask 1 - Dallas, Texas Ground Truth.....	5
2.2.2 Task 2 - Subtask 2 - Evaluation of Color Measurements	5
2.3 Task 3 - Image Shearing Eyepiece Evaluation.....	7
TABLE OF CONTENTS OF APPENDIX C.....	8
2.4 Task 4 - Viewing Illumination.....	9
2.4.1 Task 4 - Subtask 1 - Bibliography on Viewing Illumination.....	9
2.4.2 Task 4 - Subtask 2 - Viewing Illumination Considerations and Illumination Mensuration Test.....	13
TABLE OF CONTENTS OF APPENDIX D2.....	14
2.5 Task 5 - Accuracy Improvement.....	14
TABLE OF CONTENTS OF APPENDIX E.....	15

1. INTRODUCTION

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[REDACTED] began Phase II of a contract on Basic Research in Precise Measurement in April of 1971. This final report summarizes the work performed on that contract and directs the interested reader to the much more detailed final reports for each task which have been published separately as appendices to this report.

Phase II of the program of Basic Research in Precise Measurement consisted of the following five tasks.

- Task 1. Automatic Pointing
- Task 2. Evaluation of Color Measurements
- Task 3. Image Shearing Eyepiece Evaluation
- Task 4. Viewing Illumination
- Task 5. Accuracy Improvement

Technical reports were issued for each task as it ended. They are labeled as appendices to this, the final technical report for Phase II. The technical discussions, results, and conclusions for each task may be found in these appendices. The purpose of this final report is to list and summarize.

The following appendices constitute the final reports for Phase II.

	<u>Appendix</u>	<u>No. of Pages</u>	<u>Title</u>	<u>Report for Task</u>
25X1D	A	45	Automatic Pointing	1
	B1	169	[REDACTED] Ground Truth	25X1D 2
25X1D	B2	148	Mensuration Evaluation of [REDACTED] [REDACTED] Color Films	2
	C	19	Image Shearing Eyepiece Evaluation	3
	D1	97	Bibliography of Viewing Illumination	4

<u>Appendix</u>	<u>No. of Pages</u>	<u>Title</u>	<u>Report for Task</u>
D2	51	Viewing Illumination Considerations and Illumination Mensuration Test	4
D3	4	C.I.E. Color Rendering Index	4
D4	2	American National Standard-Direct Viewing of Photographic Transparencies	4
E	96	Design of an Ultra-Precise Measuring Engine	5
TOTAL	631 Pages		

Appendices A, B2, D2, D3, D4 are classified TOP SECRET.

Appendices B1, C, D1 and E are unclassified.

## 2. TECHNICAL APPROACH, RESULTS, AND CONCLUSIONS

The following paragraphs describe the work effort performed on each task.

### 2.1 Task 1 - Automatic Pointing

The work performed under this contract is a continuation of previous efforts aimed at the development of instrumentation for automatic pointing on various target types in high precision measuring equipment. The instrumentation used in the development effort has been described in some detail in previous reports (FR71-1410, January 1971).

Certain conclusions can be drawn from the test data and the experience with the most recent instrument improvements. The data quite clearly show the desirability of higher optical magnification for measurements of terrain type images, particularly when the input imagery is inherently high resolution. At the same time, there is probably little need for variable magnification, so

long as a reasonable field of view is maintained. Since the desirability of centering on large targets (300  $\mu$  diameter) seems to have diminished in time, and the shifting optical axis of a zoom lens causes alignment problems, it would probably be wise in the future to consider a fixed focal length projection lens operating at a magnification in the neighborhood of 60X. At this magnification and with currently available lenses, it should be possible for both the operator and the scanner to resolve better than 200 lines per millimeter. In addition to the improved resolution, higher magnification aids in the separation of targets which are close together and permits easier operation of the instrument.

In the test program it was noted that automatic lock on failed on certain particular types of targets. In some cases this was because of adjacent photo detail which was included in the scanned area but which did not represent the target of interest. This most frequently occurs in the corner mode, where, under the present arrangement, half of the scanned area in each axis is not the target of interest. This could be corrected in the future by offsetting the scanning slit from the optical axis when in the corner mode.

Failure on one of the targets in the corner mode was at least partially due to the way the instrument logic is set up for video polarity selection. That is, the assumption was made that the corner would be darker or lighter than the surround on both edges. In one case, due to the sun angle and the reflectances of the roof and side wall, this was not the case. This problem would probably be cured in most all cases by incorporation of the automatic video polarity select circuitry as a permanent feature in the equipment. This would allow independent polarity control in each axis as a function of the target video.

Other cases of marginal performance in very dense photo areas can usually be traced to deflection defocusing of the image dissector tubes. This results in the introduction of a false signal for large off axis sweep angles. This problem could be eliminated by the use of magnetic focus dissection tubes.

In general, while the test program has pointed up some areas where the quipment performance could be improved, the general performance on most types of targets is quite good and is representative of the state-of-the-art in such instrumentation today. The improvements in repeatability and speed of operation over that of manual techniques offer significant advantages for future operational instrumentation.

The Table of Contents of Appendix A is reproduced below:

TABLE OF CONTENTS OF APPENDIX A

<u>Section</u>	<u>Title</u>	<u>Page</u>
I	INTRODUCTION	1
II	TECHNICAL DISCUSSION	2
	Task 1 - Edge Mode Sensitivity Increase	2
	Task 2 - Automatic Scan Aperture Length Adjustment	4
	Task 3 - Addition of Fine Manual Controls	7
	Task 4 - Modification & Relocation of Oscilloscope Displays	11
	Task 5 - Reticle Projector Improvement	14
	Task 6 - Stage Calibration	16
	Task 7 - Mode Control Switches	19
	Task 8 - Automatic Video Polarity Control For Edge Detection Mode	21
	Task 9 - Comparative Test Program	24
III	CONCLUSIONS AND RECOMMENDATIONS	41
IV	APPENDIX A-I - STAGE CALIBRATION COMPUTATIONS	43



2.2 Task 2 - Evaluation of Color Measurements

Task 2 was divided into two subtasks. Subtask 1 dealt with the collection of ground truth mensuration data in Dallas, Texas. Appendix B1 details all of the results. Subtask 2 details the results of a mensuration test on a pair of [REDACTED] color frames over [REDACTED] from mission [REDACTED]

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2.2.1 Task 2 - Subtask 1 - [REDACTED] Ground Truth

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Table 1 summarizes the results of the ground truth field trip to [REDACTED]

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2.2.2 Task 2 - Subtask 2 - Evaluation of Color Measurements

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A large number of measurements have been made on the original color film, dupe positive color film and black-and-white copy [REDACTED]

25X1D

All mensuration was

25X1D

performed by a very experienced and highly competent mensuration specialist using the Center's 1210 comparators and real-time data reduction system. Ground truth over the area was collected after the frames were obtained. It is concluded, after an analysis made on sky-light lengths, widths and separations ranging from three to ninety feet that all of the color film products are of excellent mensuration quality and any can serve to give excellent mensuration results. In no case

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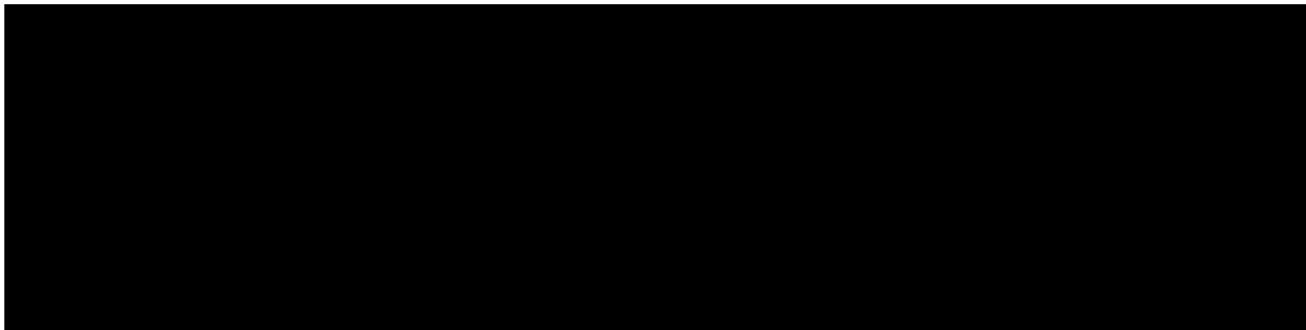


TABLE I SUMMARY OF DIMENSIONS

	SITE NUMBER	TOTAL DIMENSIONS	HORIZONTAL DIMENSIONS	VERTICAL DIMENSIONS	SKYLIGHTS	SKYLIGHT SEPARATIONS	STRUCTURES	TENNIS COURTS	CONCRETE PADS	POLE SEPARATIONS	STORAGE TANKS	PARKING LOTS	SWIMMING POOLS
	1	41	41	-	-	-	-	4	7	-	-	-	3
	14	28	24	4	-	-	1	2	2	9	-	-	-
	16	15	11	4	-	-	1	-	2	1	-	-	-
	17	24	24	-	-	-	-	2	1	5	-	1	-
	18	10	10	-	-	-	-	2	-	-	-	-	-
	34	154	148	6	48	41	1	-	-	-	-	-	-
	35	197	195	2	64	63	1	-	-	-	-	-	-
	36	527	519	8	148	216	2	-	-	-	-	-	-
	37	135	129	6	39	40	1	-	-	-	-	-	-
	39	133	125	8	32	51	1	-	-	-	-	-	-
	42	8	8	-	-	-	-	-	-	-	8	-	-
	49	10	10	-	-	-	-	2	-	-	-	-	-
	59	13	13	-	-	-	-	2	1	1	-	-	-
TOTAL	13	1295	1257	38	332	411	8	14	13	16	8	1	3

For photographic materials similar to these for viewing non-specifically colored objects against a non-specifically colored background it is concluded that excellent mensuration results can be obtained on any of the above-mentioned materials and there is no reason to expend any extra effort in obtaining a specific film type for mensuration.

These conclusions as stated mean that the three materials are nearly equally capable of giving good mensuration results over the dimension and color range investigated. They do not necessarily apply to very much larger dimensions which, however, do not usually need to be as accurate as the dimensions under one hundred feet. Nor do they necessarily apply to colored objects against a colored background, which might be more or less visible on one emulsion rather than another. That question was beyond the scope of this study. The point here is that the material is inherently capable of being precisely measured, if the object to be measured can be identified.

### 2.3 Task 3 - Image Shearing Eyepiece Evaluation

Task 3 concerns the evaluation of the Image Shearing Eyepiece concept as it is applied to measurements on photographic images. Appendix C discusses the evaluation of two devices, the Vickers Image Splitting Measuring Eyepiece and the Watson Image Shearing Eyepiece, and their application to measurements on complex photographic images. It is concluded that both devices are inherently accurate enough to make precise measurements on small, well-defined, isolated images whose contrast differs greatly from the background. Because of its added flexibility, the Vickers Image Splitting Measuring Eyepiece with auxiliary direct dimensional readout would be the device of choice. Unfortunately, typical photography of complex scenes could not be measured with either device. At present, there is no known application on continuously varying greyscale photographic imagery on which either device would perform satisfactorily.

The Table of Contents for Appendix C is reproduced below:

TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
1.	INTRODUCTION.....	1
1.1	Background.....	1
1.2	Purpose and Scope.....	1
2.	TECHNICAL APPROACH.....	1
2.1	Image Shearing Eyepiece Concept.....	1
2.2	Evaluation of the Vickers A.E.I. Image Splitting Measuring Eyepiece.....	3
2.2.1	Description of the Vickers Image Splitting Measuring Eyepiece.....	6
2.2.2	Vickers Image Splitting Measuring Eyepiece Test Results.....	8
2.2.3	Use of Vickers Eyepiece on Photographic Images..	9
2.3	Evaluation of the Watson Image Shearing Eyepiece	13
2.3.1	Description of Watson Image Shearing Eyepiece...	13
2.3.2	Watson Image Shearing Eyepiece Test Results.....	14
2.3.3	Use of Watson Image Shearing Eyepiece on Photographic Images.....	17
2.4	Design Considerations.....	17
2.4.1	Vickers Direct Dimensional Readout.....	17
2.4.2	Vickers Binocular Image Shearing Measuring Microscope.....	18
3.	CONCLUSIONS.....	18
4.	RECOMMENDATIONS.....	18

2.4      Task 4 - Viewing Illumination

Task 4, for convenience, was divided into two subtasks. The first part of this task, the literature search, resulted in a bibliography of 582 references. The second part of the task was an application of the available knowledge on viewing illumination to the Center's mensuration effort.

2.4.1    Task 4 - Subtask 1 - Bibliography on Viewing Illumination

A bibliography on the general topic of viewing illumination is given in Appendix D1. The bibliography contains 582 references which are listed alphabetically and cross-index. Selected summaries of the more pertinent references are provided. The search terms used are listed in Figure 1.

The open literature search included the broad categories of illumination, illuminants, human visual behavior, color science, color vision, viewing and display systems. Document search was generally for the period 1960-1971.

Reference sources most widely quoted are Applied Optics, Illuminating Engineering, Journal of Experimental Psychology, Journal of Society of Motion Picture and Television Engineers, Journal of the Optical Society of America, Photographic Science and Engineering, Vision Research.

The Subject Headings of the bibliography are listed in Figure 2.

FIGURE 1.  
SEARCH TERMS

DDC/NASA SEARCH

SUBJECT: ILLUMINATION/HUMAN FACTORS  
(BROAD COVERAGE)

KEY WORDS

- |                              |                                  |
|------------------------------|----------------------------------|
| A. Color Photography         | G. Color Vision/Visual Defects   |
| 1. Color Film                | H. Color Vision/Visual Reception |
| B. Color Temperature         | I. Colorimeters                  |
| 1. Blackbody Radiation       | 1. Color                         |
| 2. Emissivity                | 2. Colorimetric Analysis         |
| 3. Spectral Emmittance       | 3. Colorimetry                   |
| C. Color Vision              | J. Human Factors Engineering     |
| D. Lamps                     | 1. Comfort                       |
| 1. Arc Lamps                 | 2. Performance                   |
| 2. Electroluminescent Lamps  | 3. Psychological Effects         |
| 3. Fluorescent Lamps         | K. Light (Visible Radiation)     |
| 4. Gas Lamps                 | L. Visibility                    |
| 5. Glow Lamps                | 1. Contrast                      |
| 6. Incandescent Lamps        | 2. Light                         |
| 7. Infrared Lamps            | 3. Resolution                    |
| 8. Mercury Lamps             | M. Visible Spectrum              |
| 9. Neon Lamps                | N. Visual Perception             |
| 10. Neon Tubes               | 1. Flicker                       |
| 11. Sodium Lamps             | 2. Critical Flicker Fusion       |
| 12. Ultraviolet Lamps        | O. Illuminance                   |
| 13. Xenon Lamps              |                                  |
| E. Brightness                |                                  |
| 1. Color                     |                                  |
| 2. Glare                     |                                  |
| 3. Human Factors Engineering |                                  |
| 4. Incandescence             |                                  |
| 5. Radiance                  |                                  |
| 6. Reflectance               |                                  |
| F. Color                     |                                  |
| 1. Chroma                    |                                  |
| 2. Color Codes               |                                  |
| 3. Color Matching            |                                  |
| 4. Color Temperature         |                                  |
| 5. Comprehension             |                                  |
| 6. Contrast                  |                                  |

FIGURE 2  
SUBJECT HEADINGS

- I. COLOR
  - 1. Color (General)
  - 2. Colorimetry
  - 3. Color Matching
  - 4. Color Photography
  - 5. Color Specification
  - 6. Color Theory
  
- II. COLOR VISION
  - 1. Chromatic Adaptation
  - 2. Color Contrast
  - 3. Color Discrimination
  - 4. Color Vision (General)
  - 5. Color Vision Theory
  - 6. Visual Mechanism
  
- III. ILLUMINANTS
  - 1. Arc Lamps
  - 2. Color Rendering
  - 3. Color Temperature
  - 4. Discharge Lamps
  - 5. Electroluminescent Lamps
  - 6. Fluorescent Lamps
  - 7. Incandescent Lamps
  - 8. Spectral Distribution

IV. ILLUMINATION

1. Design Guides/Standards
2. Flicker
3. Glare
4. Illumination (General)
5. Luminance
6. Photometry
7. Visual Performance

V. VIEWING SYSTEMS

1. Design Guides
2. Direct Viewing/Stereoscopic
3. Other
4. Projection

VI. VISION

1. Accommodation
2. Acuity
3. Adaptation
4. Brightness
5. Contrast
6. Interpretation Performance
7. Physiological Factors
8. Psychological Factors
9. Spectral Sensitivity
10. Vision (General)



2.4.2 Task 4 - Subtask 2 - Viewing Illumination Considerations and Illumination Mensuration Test

Appendix D2 discusses basic factors involved with viewing illumination as applied to the Center's mensuration mission. A mensuration test was performed under five different illumination conditions to study the affects of the concepts developed using operational imagery. The results of the mensuration test indicate that as long as the illumination does not degrade the appearance of the image and the contrast at the image edge, or affect the comfort of the operator, the precision of the mensuration results, under current standards, will probably not be affected. One hundred eleven separate measurements were made on dupe positive color film under each illumination condition to verify these results.

Appendix D3 describes the C.I.E. Color Rendering Index and presents the color rendering index of various illuminants.

Appendix D4 presents the American National Standard Institute (ANSI) Standard PH2.31-1969 on Direct Viewing of Color Transparencies.

For neutrally colored objects against a neutral background, precise measurements on color film may be obtained with the Mann green filter in place. Where the green filter might mask the contact of a color edge, nearly equally precise measurements may be made under white light conditions. A red filter may be introduced in order to emphasize a color contact at no loss in mensuration precision. Under the range of illumination employed, the color appearance of an object seems to have no affect on its ability to be precisely measured as long as the color contact between the object and background can be clearly identified. Any attempt to modify the color of the light source to enhance the recognition of that contact should not degrade the precise mensurability of the image. It is recommended that the above guidelines as to light source color be followed under production mensuration conditions.

The Table of Contents for Appendix E2 is shown below:

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1. INTRODUCTION.....	1
1.1 Purpose.....	1
1.2 Scope.....	1
2. TECHNICAL APPROACH.....	2
2.1 Basic Considerations.....	2
2.1.1 Illuminants and Illumination Systems.....	2
2.1.1.1 Illuminants.....	2
2.1.1.2 Illumination Systems.....	6
2.1.2 Mensuration Materials.....	8
2.1.3 Vision.....	15
2.1.4 Summary.....	22
2.2 Illumination Mensuration Test.....	23
2.2.1 Measurement Results.....	23
2.2.2 Conclusions of Mensuration Test.....	31
3. CONCLUSIONS AND RECOMMENDATIONS.....	35
4. PRESENTATION OF DATA.....	35

2.5 Task 5 - Accuracy Improvement

Appendix E deals with certain factors affecting the geometric quality of black-and-white images and of colored images, and with the effects of these and other factors on the design of an ultra-precise ( $\pm 0.1\mu$ ) measuring system. The Table of Contents for Appendix E is given on the following pages.

## APPENDIX E

## TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
1.	INTRODUCTION	1
1.1	Purpose of Work	1
1.2	Summary of Previous Work on Problems of Precise Measurement on Color Photography	4
2.	DEFINITION OF THE GEOMETRIC ELEMENTS OF AN IMAGE	7
2.1	Origin of Edges	9
2.2	Relation of Image Edges in Black-and-White Photography to Image Edges in Color Photography	10
2.2.1	Edges in Pictures Developed by Polygamma Processes	11
2.3	Definition of Edge	12
2.4	Origin of Point Images	15
2.5	Definition of Image Point	16
3.	EDGE PERTURBATIONS	17
3.1	Review of Edge Perturbations	17
3.2	Edge Perturbations Common to All Measuring Systems	20
3.2.1	System Diffraction Effects	21
3.2.1.1	Diffraction Effects Caused by the Photographic Image	22
3.2.1.1.1	Diffraction by an Infinitely Long Straight Edge	24
3.2.1.1.2	Diffraction Patterns of Circular and Rectangular Images	28
3.2.1.1.2.1	Diffraction by Circular Image	28
3.2.1.1.2.2	Diffraction by Rectangular Image	29
3.2.1.1.2.3	Diffraction by Photographic Images Having Indistinct Edges	30
3.2.1.1.3	Effect of Diffraction by Image on Design	34
3.2.1.2	Diffraction by System Elements	35

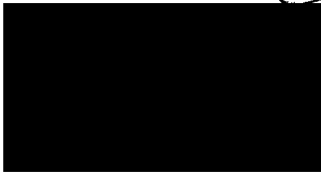
## TABLE OF CONTENTS (cont)

<u>Section</u>		<u>Page</u>
3.2.1.2.1	General Theory	35
3.2.1.2.2	Diffraction by a Circular Aperture	38
3.2.1.2.3	Effect on Optical Image	44
3.2.1.3	Total Diffraction Effect	46
3.2.2	Illumination of Photographic Image	48
3.2.2.1	General Considerations	50
4.	PRINCIPLES OF DESIGN OF MEASURING INSTRUMENT	58
4.1	Review and Implications of Definition	59
4.2	Correlation Theory Applied to Measurement	59
4.2.1	Correlation Along Profile	60
4.2.2	Correlation Over a Region	62
4.2.2.1	Geometric Method	63
4.2.2.2	Statistical Method	63
4.2.3	Extension to Colored Images	64
4.3	Design Based on Profile Characteristics	64
4.4	Design using Correlation over Area (Texture Analysis)	64
5.	MAJOR FEATURES OF MEASURING SYSTEM DESIGN	68
5.1	Block Structure of System	68
5.1.1	Other Considerations	69
5.2	Viewing Subsystem (VSS)	69
5.3	Measurement/Detection Subsystem (MSS)	72
5.3.1	Illuminating SSS	72
5.3.2	Stage	72
5.3.3	Detector Subsystem	75
5.3.4	Impersonal Location System	75
5.3.5	Measuring Subsystem Proper	76
5.4	Computing and Recording Subsystem	76
6.	SUMMARY AND CONCLUSIONS	77

TABLE OF CONTENTS (cont)

<u>Section</u>		<u>Page</u>
Appendix E.1	EFFECT OF DUAL-GAMMA OR POLY-GAMMA DEVELOPMENT PROCESSES ON EDGES	79
Appendix E.2	COMMENTS ON MINOR ITEMS AND DETAILS IMPORTANT IN DESIGN	89
Appendix E.3	EDGE PERTURBATIONS CAUSED BY DEVELOPMENT	91
Appendix E.4	DIFFRACTION BY A STRAIGHT EDGE	92
	LIST OF REFERENCES	94

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TCS 175-2015/72

Final Report

June 1977

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